

the AN/TTC-39

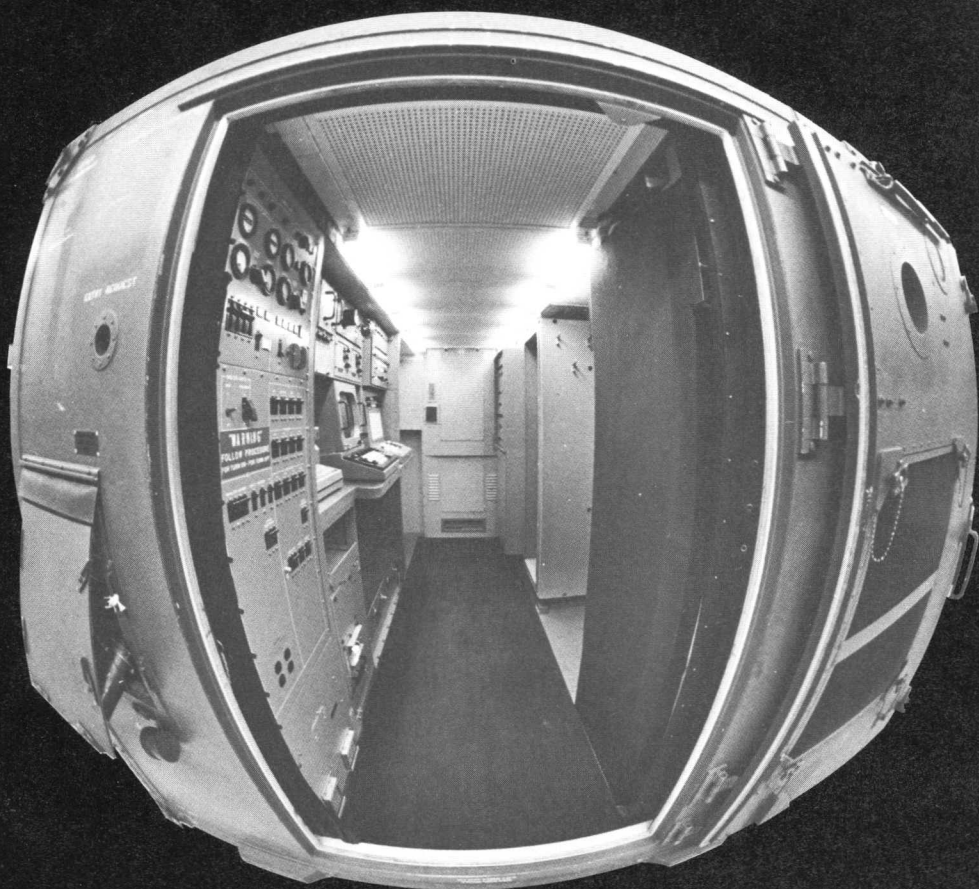
TRI-TAC FAMILY OF CIRCUIT AND MESSAGE SWITCHES



GTE SYLVANIA

the AN/TTC-39

TRI-TAC Family of Circuit and Message Switches —
designed to ease the transition from analog to digital military communications



DIGITAL COMMUNICATIONS

For decades, the US Department of Defense (DOD) has examined digital telecommunications in anticipation of the time when technology would make this method viable. This time has come, and the long-awaited improvements in performance and physical characteristics can be provided.

In the 1960's, the Mallard Program, a multi-national program to develop and implement an all-digital tactical telecommunication network, was started. It was rejected by the US Congress as being too early for the state-of-the-art, too complex due to

multi-service and multi-national requirements and, last, and perhaps most significant, as providing no method for effectively utilizing the significant investment in analog inventory systems and equipments.

Military communicators are anxious to "get into" digital communications for performance quality, lower cost, reduced size and weight, and integrated voice and data capability.

TRI-TAC

In 1971, the Department of Defense established the Joint Tactical Communication Office (TRI-TAC) to design and implement a tri-service tactical communication system which would: (1) make efficient use of the existing analog inventory, (2) establish common standards for the emerging digital communications, and (3) utilize the rapidly improving digital technology.

TRI-TAC evolved a system architecture and specified equipments, considering the analog-to-digital transition. Equipments include a family of communication switches, digital tropo, digital facsimile, multiplexers, and technical control facilities.

AN/TTC-39 CIRCUIT SWITCH

The AN/TTC-39 is a multi-purpose, 4-wire, tactical central office which is both hybrid and modular.

The 600-line and 300-line switches have electrically and mechanically interchangeable switch matrices which can be either analog (space division) or digital (time division). The proportion of space to time-division matrices may be changed after the switches have been put into service so that the switches provide optimum services in a changing communications environment. This architecture provides for analog switching, and for connections between analog and digital subscribers and trunks, and extends the life of the AN/TTC-39 switch equipment from its 80 percent analog, 20 per cent digital mix at initial fielding to the time when the military telecommunication plant is predominantly digital.

Subscriber features

The following subscriber features are available to analog and digital subscribers:

- *Precedence and Pre-emption (5-level AUTOVON compatible)*
- *Preprogrammed and Progressive Conferencing (maximum 20 parties)*
- *Broadcast Conferencing (maximum 30 parties)*
- *Call Transfer*
- *Call Forwarding*
- *Abbreviated Dialing*
- *Off-Hook Service (40 subscribers)*
- *Fixed Directory for Mobile Subscribers*
- *Attendant Recall*
- *Automatic Intercept*
- *Recorded Announcements*
- *Special Service Classmarks*
- *Essential User Bypass*
- *Full Operator Service*

THE AN/TTC-39 FAMILY OF SWITCHES

The AN/TTC-39 Program provides a family of communication switches which play a major role in the Tri-Service Tactical (TRI-TAC) Communication System. This family consists of two types of switches, circuit and message, which perform different but complementary functions.

The Circuit Switch handles analog and digital voice as well as data communication.

The Message Switch handles data exclusively for store and forward service.

Together, the switches will provide automatic switching service for voice traffic and store-and-forward service for data traffic in an integrated fashion. Means are available for switching message traffic into a circuit-switched network.

The AN/TTC-39 switches are hybrid, modular, transportable, tactical automatic switching equipments. They use microelectronic components and design techniques to insure minimum size, weight and power consumption, and are stored-program controlled. The switch equipment modules are mounted in S-280 shelters for high mobility, or the modules can be "dismounted" and placed in fixed-plant or van-mounted configurations. Capabilities have been incorporated for utilizing the switches in strategic, as well as, tactical applications.

Numbering plan

The primary numbering plan for AN/TTC-39 is the MIL-STD-188C PR-SL-XXX plan. PR is area code, SL is switch location, and XXX is subscriber extension.

It is also programmed to provide the strategic (AUTOVON) plan of 10 digits, including 3-digit area code, 3-digit switch location, and 4-digit subscriber extension (NYX) NNX-XXXX.

Routing

The Circuit Switch is for use in a non-hierarchical mesh network with a deterministic routing plan, allowing originating office control or spill forward. Routing is the logical process that involves the mechanics of converting and processing address and data base information. It includes the interactions of number plan, translation, alternate routing, and editing, and special features such as direct access, fixed directory, call transfer, compressed dial, pre-programmed conferencing, operator recall/call forwarding, line hunting, precedence, zone restriction, and call inhibit.

Load control

Two types of traffic flow restrictions are implemented, one restricting subscribers from gaining access to the trunk network, and the other restricting subscribers from obtaining access to the switch.

Interfacing equipment

The Circuit Switch, by its nature, is a versatile interfacing device, interconnecting one subscriber instrument (loop) or Circuit Switch (trunk) to another loop or trunk. The Circuit Switch Loop interfaces include various types of existing military and commercial telephone instruments.

Trunk interfaces include a wide variety of existing commercial and military switches including manual ringdown boards, AUTOVON, NATO, Commercial Offices, and other automatic switches such as the AN/TTC-38. In addition, the Circuit Switch must, of course, interface with other AN/TTC-39 Circuit and Message Switches.

Implementation

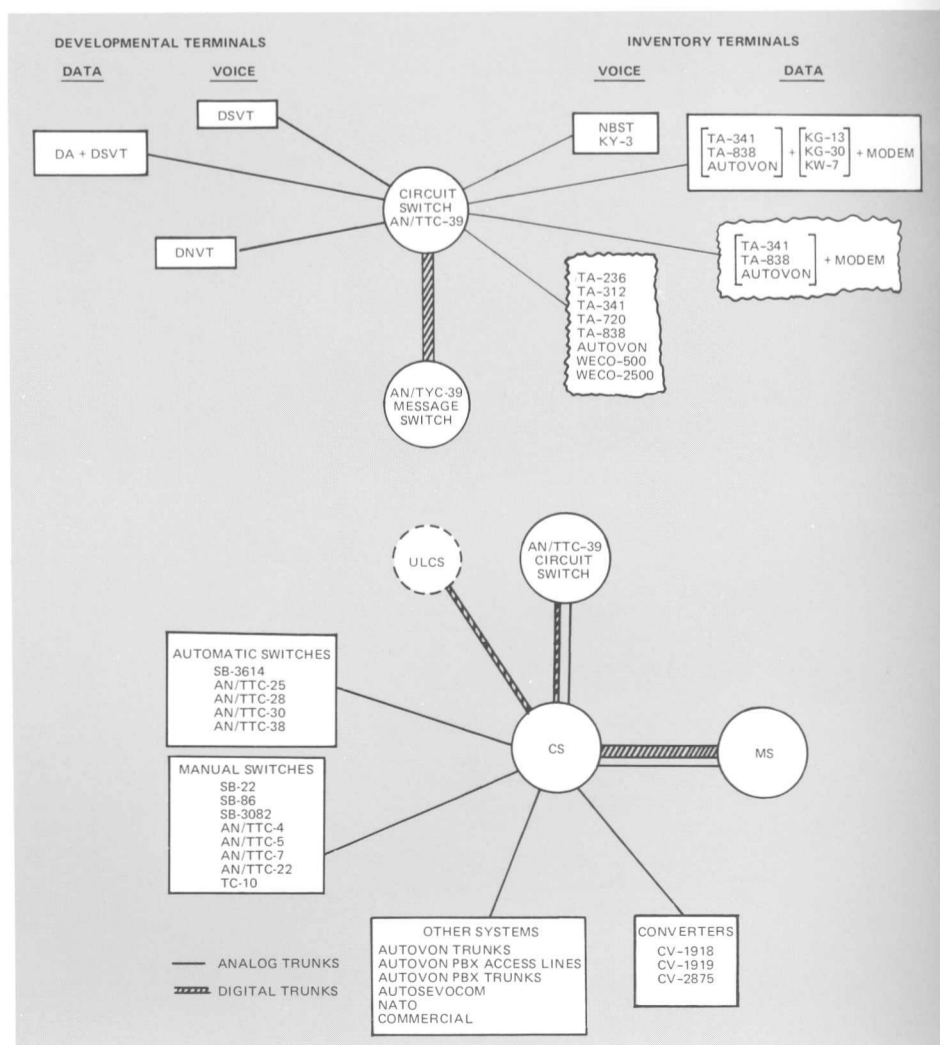
Signaling and supervisory protocols as well as routing and numbering plan features are performed by software. Switching and line interface are allocated to hardware. There are two types of switch matrices—an analog space division matrix using silicon-controlled switch crosspoints in 4 x 4 integrated circuit packages and a time division matrix using digital integrated circuits to form 64-channel memories. These memories are interconnected to form a non-blocking time division switch of up to 960 terminations (four switch modules) with each single digital switch module (time division switching group, TDSG) containing from three to five 64-channel memories.

The space division switch is a 4-stage, 4-wire matrix with a single module (space division switching group, SDSG) providing 156 terminations, of which 36 are for internal service equipments. Up to four SDSGs may be interconnected to form a 624-termination analog switch with a probability of blocking less than 0.001 at the full 180-Erlang traffic load.

Interface between the matrix equipments, their associated signaling, supervisory and line termination equipments, and the processors is provided by means of three hardware controllers, each of which is redundant. Each controller performs formatting and I/O protocol between the devices it services and the central processor. Interface with the processor is via direct memory access channels, thus freeing software from performing detailed repetitive I/O operations.

External equipments terminating on the digital matrix are of three types: (1) single-channel digital loops operating at 16 or 32 kb/s and using signaling and supervisory protocols in accordance with the TRI-TAC digital loop signaling plan, (2) single-channel analog loops us-

ing MIL-STD-188C standards, and (3) digital transmission groups (DTG) containing from 8 to 144 time division multiplexed 16- or 32-kb/s channels. Format and synchronization protocols of the DTG are fully compatible with other interfacing TRI-TAC family equipments. The baseband DTG signal can be modulated using either diphasic or dipulse techniques. Buffer and framing units provide frame synchronization and absorb clock drift effects to guarantee a minimum 24-hour time period between resynchronization.



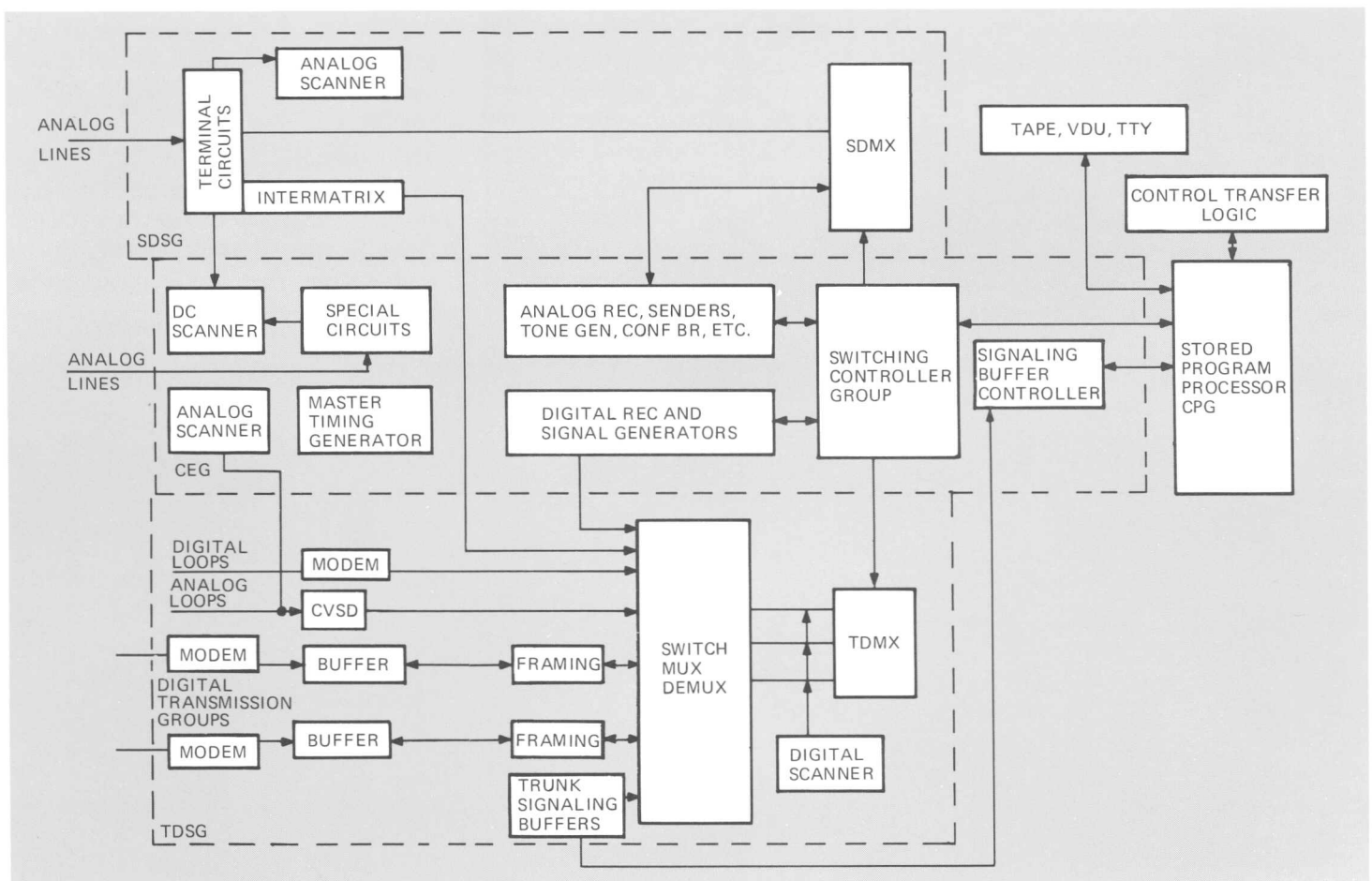
Interfacing Equipment and Systems

Single-channel digital loops are di-phase modulated at 16 or 32 kb/s, use CVSD speech conversion techniques, and interface to the Circuit Switch via di-phase loop modems. Analog loops interface the TDSG via CVSD terminations which output a 16- or 32-kb/s baseband signal to the switch multiplexers. Scanning and signaling functions are performed prior to CVSD conversion by means of an analog scanner and a receiver matrix unit which provides for the connection of DTMF receivers to the up-to-60 analog loops. Baseband signals pass through various stages of multiplexing and demultiplexing, during which they are brought down to single channels (at 16 or 32 kb/s) and up to 64-channel groups to interface with the 64-channel time division switch memories.

Lines terminating on the space division switch interface via one of eight types of terminal circuits and/or one of four types of special circuit adapters. A special termination, the intermatrix unit, interconnects the space and time division matrices. It is the function of the terminal circuits and adapters to provide the electrical interface to a class of loop and trunk equipments, while the software provides the specific signaling/supervisory protocol for each loop and trunk type. Supervisory signals are passed from the terminal circuits and adapters to scanning equipment which performs signal detection, processing computer interface functions. Signaling is provided by means of pooled DTMF and MF receivers and DTMF/MF senders. Dial pulse signaling is detected by the DC scanner.

Signaling between AN/TTC-39 switches is accomplished using out-of-band common channel signaling in the DTG or a separate analog trunk. System timing is provided by crystal clocks which can be slaved to timing derived from an incoming DTG.

In addition to its complement of switching equipment, the AN/TTC-39 Circuit Switch provides a set of peripheral equipments consisting of two magnetic tape units, a video display unit, and two teletype-writers for the loading of programs and data base, modification of data base, output of fault and status reports and requests for execution of maintenance routines. An attendant (operator) position is provided within the shelter and up to three additional remote positions can be accommodated.



Circuit Switch Functional Partitioning

Software and processing

The central processor in control of the system has 262K, 33-bit words of memory, can accommodate 24 I/O channels, and is fully redundant. Under normal operation, one processor is active (processing traffic) and the other standby (performing on-line diagnostics). Loss of the active processor's keep-alive signal causes the control transfer logic to automatically connect the switching equipments to the standby processor. Switchover is accomplished without the loss of any established call.

Circuit Switch software is provided for both on-line control and operations and for off-line diagnostics.

The on-line control and operational program is structured into four subprograms: operating system, call processing, man-machine, and maintenance and diagnostics (M&D), with the subprograms further divided into modules and units.

Subprogram interaction is through the global data base. Operating system functions include scheduling of the other subprograms and modules, providing I/O control, and performing switchover and recovery. The call processing subprogram performs all signaling, supervision, translation and routing, while the man-machine subprogram provides for the interaction of the switch supervisor with the system and the M&D subprogram provides fault detection capabilities.

The number of instructions by subprogram module is summarized below.

Configuration and physical characteristics

The two-shelter version of the switch is provided in a 600-line configuration and includes the Space Division Switching Group (up to a maximum of four), Time Division Switching Group (up to a maximum of four), a Common Equipment Group, Call Service Position, Central Processor (with peripherals); Special Circuits Group, Operator/Maintenance Position, and the Power Subsystem.

A non-expandable 300-line Circuit Switch includes the same family of subsystems with three interchangeable matrices in a single S-280 shelter.

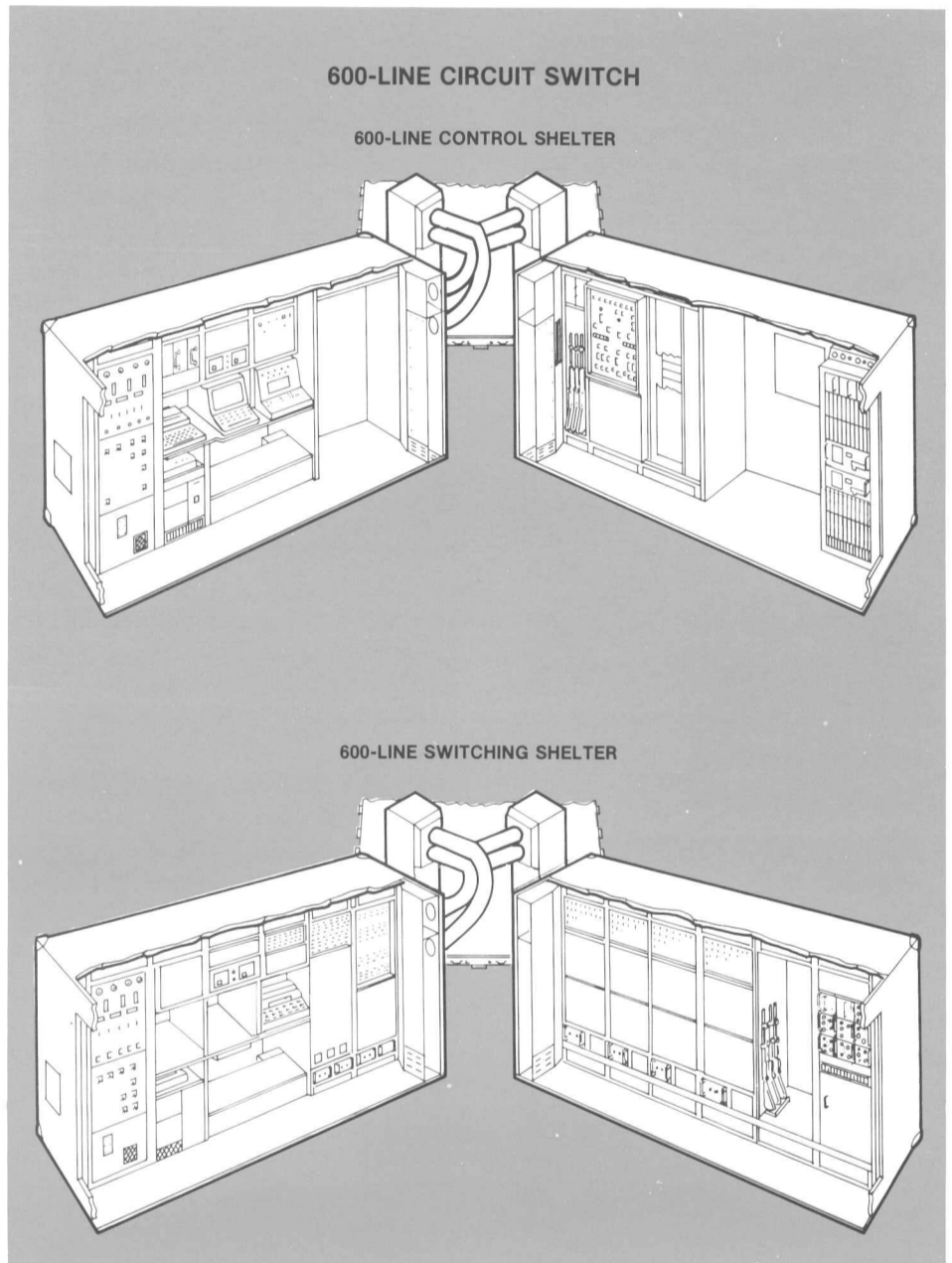
The shelters are the US Army Standard S-280 shelter with dimensions of 7 feet x 7 feet x 11 feet. Dual Environmental Control Units and cable reels are carried on a separate pallet.

	CORE	TAPE	TOTAL INSTRUCTIONS
Operating System	11,198	—	11,198
Call Processing	70,599	—	70,599
Man-Machine	15,063	71,742	86,805
Maintenance and Diagnostics	7,216	26,572	33,788
Data Base (Words of Core)	42,170	—	42,170
			Total 244,560

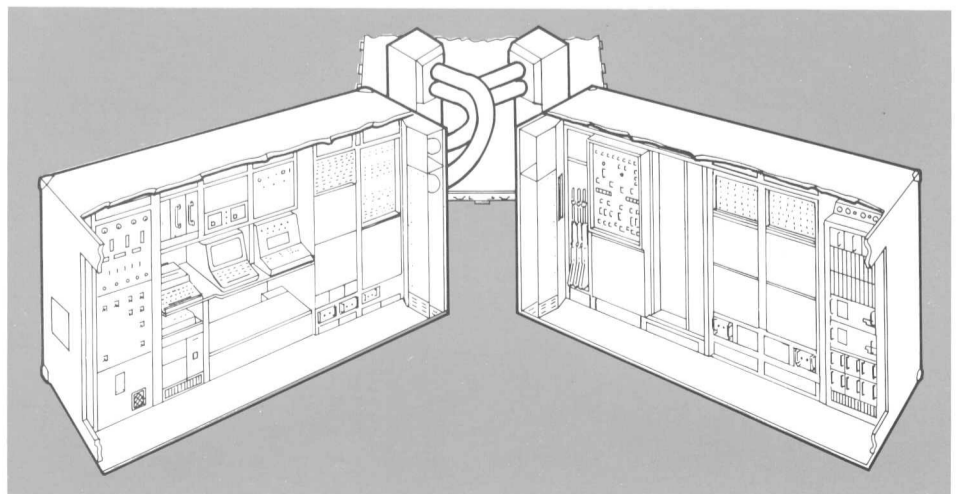
The equipment was tested to the environmental requirements of MIL-STD-810B.

Summary of performance characteristics

- Dial tone delay – less than 1 second
- Traffic – 180 Erlangs
- Call Rate – 5000 to 7500 in the busy hour
- Blocking – less than one call in 1000 analog and non-blocking digital
- Cross office connection – less than 1.0 second
- Number plan – 7- or 10-digit
- Precedence – 5 levels
- Abbreviated dialing – 3- or 4-digit
- Routing – Primary plus 5 alternates
- Availability – 0.9999
- Analog bandwidth – 108 kHz
- Digital rates – 16 kb and 32 kb
- Error protection – up to 0.1% (random (BER), also 5% burst to 20% (BER)).



600-Line Control Shelter and Switching Shelter



Shelter Layout – Single Shelter Circuit Switch, 300-Line

MESSAGE SWITCH — FUNCTIONAL DESCRIPTION

The Message Switch AN/TYC-39, in 25- and 50-line versions, provides the store and forward capability of receiving and delivering message traffic for both dedicated and switched subscribers in tactical and strategic (AUTODIN backbone) environments. Subscribers can be from Strategic (R), Tactical (U), and Intelligence (Y) communities using JANAP 128, ACP 127, and ACP 127 modified formats, operating in AUTODIN Modes I through V, and also in TRI-TAC Mode VI when used in conjunction with a Data Adapter.

Subscriber and service features

- **COMMUNICATIONS SECURITY**

Eight levels of message security are provided.

- **Routing**

The Message Switch utilizes a 4 – 7 character alphabetic routing indicator for the R, U, and Y communities providing for both individual and collective routing.

- **MESSAGE PROCESSING**

Messages are handled with an average processing time of two seconds with message queuing determined by six levels of precedence.

- **SERVICE MESSAGES**

Service messages are transmitted to the message originator in response to a message header error, for data channel testing or to acknowledge receipt of messages.

- **TAPE STORAGE**

Combined reference and journal files are contained on short and long history tapes. Messages may be traced and retrieved for up to one and 30 days respectively.

Message traffic is stored (on intercept tape) for deferred delivery when immediate delivery is not possible.

A temporary in-transit storage overload condition during peak traffic periods is relieved by overflow tape storage.

- **ACCOUNTABILITY**

The Message Switch maintains absolute accountability of all message traffic accepted by the switch.

Under failure conditions necessitating a system restart, a journal balance is performed to guard against loss of a message by the switch. The Message Switch protects against loss, error transmission, or misrouting of message by detecting equipment failure or transient error condition.

- **RECOVERY**

Provision is made to automatically recover from a failure of the processing equipment. Automatic equipment reconfiguration and redundant storage of software programs allows resumption of normal message processing functions in a matter of seconds. Message recovery capabilities provide for those messages which were not delivered.

Implementation

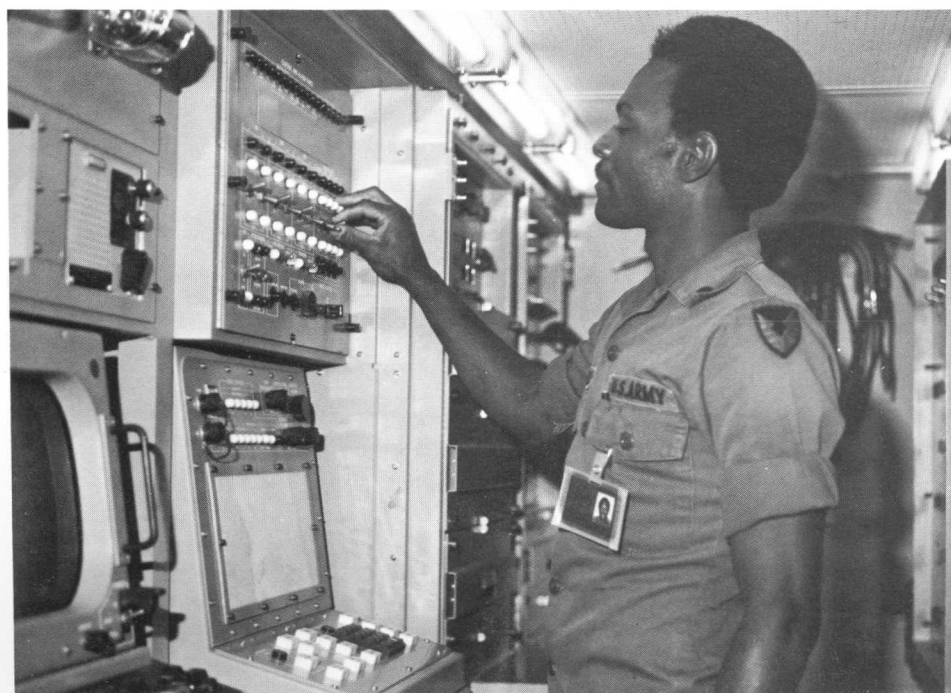
- **MESSAGE PROCESSING**

Time Division Switch (TDS) trunks, Space Division Switch (SDS) trunks and dedicated lines terminate on the Message Switch. The 32-channel TDS trunk group is terminated at the Time Division Interface which recovers the individual channels. Signaling and SYSCON information are transferred directly to the on-line Message Processor, while the remaining channels are connected selectively to Line Termination Units (LTU).

Each SDS trunk and dedicated line is terminated at a modem which converts the FSK or diphase signal to a digital baseband signal which is connected to an LTU.

Line Termination Unit outputs are routed to the Communication Interface Processor (CIP) for processing and formatting prior to transmission to the Message Processor (MP).

The MP stores, validates message headers, and routes incoming messages; makes the selection of the message for output; performs



Circuit Switch

message format and media conversion; provides message accountability; provides the capability to retrieve messages, and notifies the Operator/Maintainer and Traffic Service Attendant in the event of equipment failures or message error conditions.

When the MP has a message to be transmitted, it transfers the message in segments to the CIP which handles the message segment and transfers to the Line Termination Unit.

The LTU transmits characters, after multiplexing for lines and trunks, in a bit serial fashion, either asynchronously, or synchronously, depending on classmark.

● STORAGE

The Message Switch provides storage in such a manner that message integrity is insured under all conditions of Message Switch equipment degradation. Four categories of message storage are provided by the Message Switch: In-transit (Disc), Intercept, Overflow, and History (Tape).

Disc Storage

Two Random Access Storage (RAS) units store control functions, in-transit messages, and on-line programs.

Tape Storage

Eight Magnetic Tape Transports per Message Switch

A **Short History Tape** contains a composite of the journal and reference information and is retained for 24 hours.

A **Long History Tape** contains up to 10,000 character blocks including the Short History records. It is retained for 30 days.

Intercept Storage Tape is provided for temporary storage.

Overflow Storage Tape is a secondary level of in-transit storage, when the RAS is filled.

● SOFTWARE AND PROCESSOR

Redundant processors with 131 thousand words of core mem-

ory are provided for message processing and standby processing. Message Switch software is organized into on-line and off-line programs. On-line programs include 17 modules in four groups, whereas the off-line programs consist of ten modules in four groups.

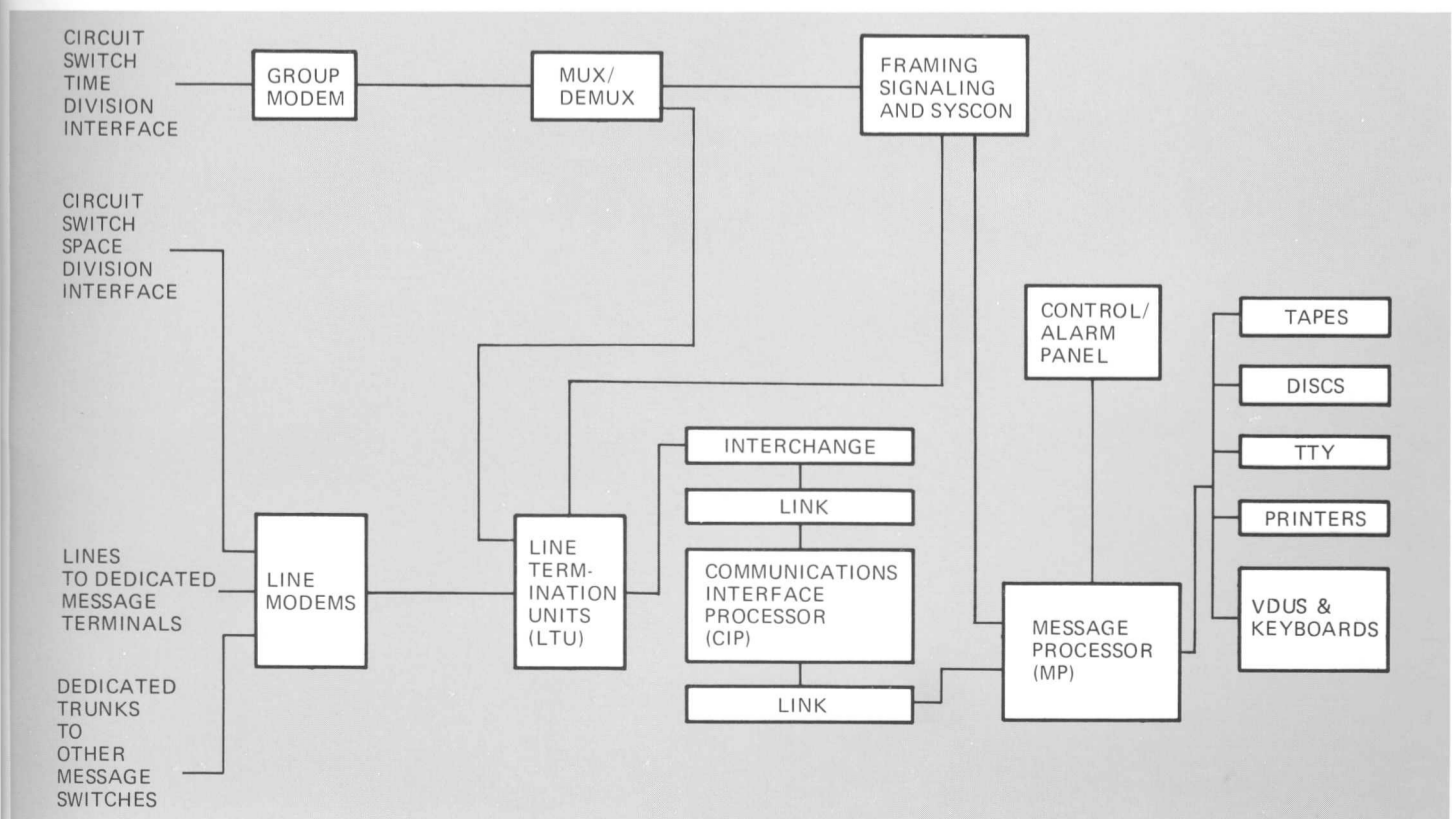
On-Line Groups

Control Group

The control group controls and monitors the on-line program and controls all the I/O. It contains the On-Line Executive, Startup, and Restart modules.

Traffic Group

The traffic group accepts and validates segments of messages from input lines, converts to various formats, links messages to appropriate Routing Indicator (RI) and destination, makes journal and history entries, retrieves from storage, and converts formats for various output line types. It monitors the traffic for overloads, backlogs, full tables and queues, and timeout functions, and prepares various service messages and printouts.



Message Switch Functional Partitioning

Operator Group

The operator group provides for a man-machine interface.

Special Interface Group

The special interface group provides special control and processing interfaces for message exchanges with Circuit Switch Interface (CSI), and Data Adapter Interface (DAI).

Off-Line Groups

Off-line groups include Executive, Support, Message Related and Data Reduction.

• OPERATOR INTERFACES

There are four functional areas of operator interaction with the operational program which have been implemented with Visual Display Units, Keyboards, Magnetic Tapes, and Line Printer Units (LPU).

The **Switch Supervisor** enters commands into the system and monitors the status of the system.

The **Traffic Service Operator** receives copies of service messages sent to subscribers by the Message Switch and messages addressed to the Message Switch.

The **On-Line Maintenance** function is performed using the Switch Supervisor's position or the Teletypewriter (TTY) located in the Communications Interface Shelter (CIS).

There are off-line programs for maintenance functions, statistical reports, new program and supervisory input tapes which list the contents of tapes, disc files, or core memory, and perform certain message-related functions to support those performed by the on-line system.

Configuration and physical characteristics

The 25- or 50-line Message Switches comprise two S-280 shelters and auxiliary pallets containing Environmental Control Units and cable reels. Included in the Communications Interface Shelter (CIS) are the Modems, Time Division Interface Group, Patching, Line Termination Units, Communications Interface Processor, TTY, and a Power Sub-System. Housed in the Message Processing Shelter are the Automatic Data Processor and Memory, Random Access Storage Units (2), Magnetic Tape Transports (8), VDU/KBs (3), High-Speed Printers (3), and a Power Subsystem.

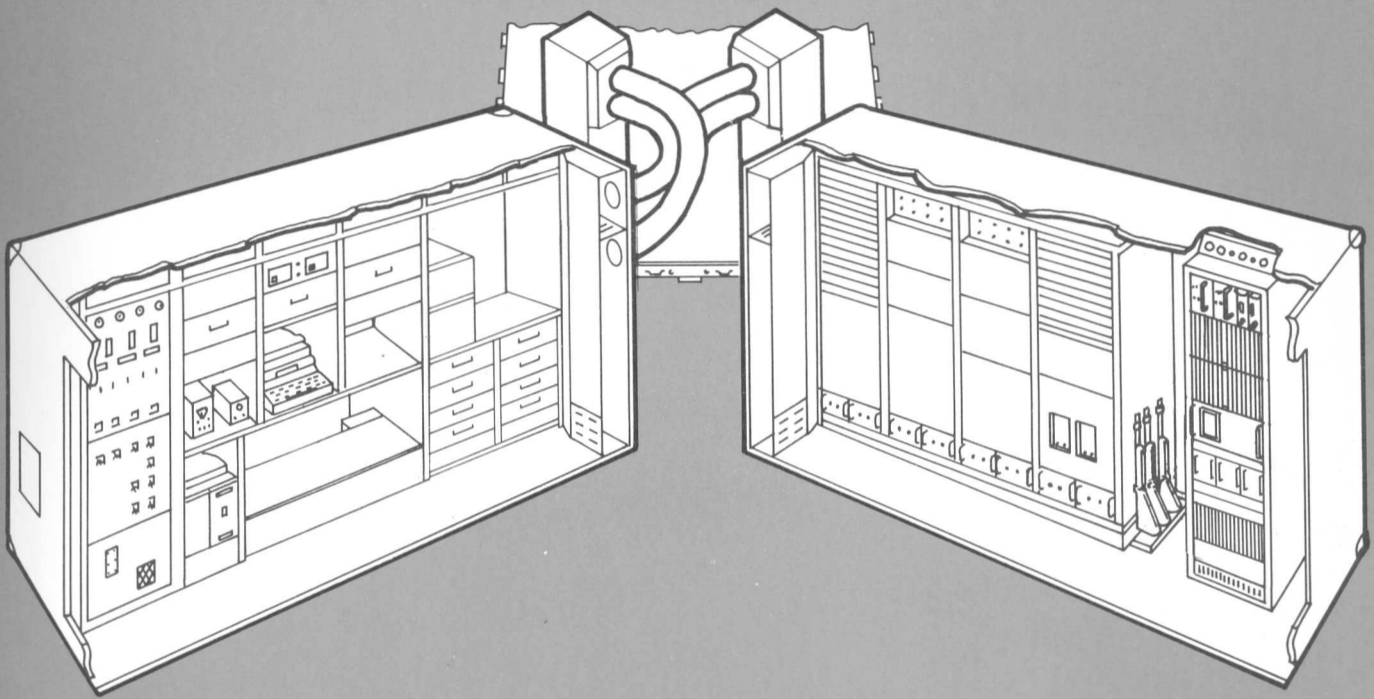
The equipment has been tested to the environmental requirements of MIL-STD-810.

Summary of performance characteristics

- Average message processing time – 2 seconds
- Output bit error rate – less than one error in 10^{10} consecutive bits
- Misrouting – less than one message in 10^7 messages
- Loss in or no transmission – less than one in 10^9 messages
- Peak throughput (50 lines) – 81 million characters per day
- Maximum message length – 44,000 characters
- In-transit storage (for 2400-character message) – 2400 messages
- Routing indicators – 4- to 7-character
- Availability – 0.9999
- Message retrieval
 - Flash, critic and ECP less than 24 hours old – 7 minutes
 - All other messages less than 24 hours old – 15 minutes
 - All traffic over 24 hours old – 30 minutes
- Maximum number of routing indicators per message – R and U Community – 50 – Y Community – 500
- Security levels – eight
- Precedence levels – six
- Data rates – 45 to 16,000 baud.

ON-LINE	CORE	DISC/TAPE	TOTAL INSTRUCTIONS
Control	21,000	5,750	26,750
Traffic	12,700	20,400	33,100
Operator		20,450	20,450
Special Interface	6,300	4,800	11,100
Communication Interface	24,200		24,200
OFF-LINE			
Executive		8,500	8,500
Support		14,000	14,000
Message Related		24,800	24,800
Data Reduction		9,300	9,300
Data Base (Words of Core)	82,350		82,350
			Total 254,550

COMMUNICATIONS INTERFACE SHELTER



MESSAGE PROCESSING SHELTER

